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STUTTGART INTERCONNECTION NETWORK PROJECT FROM PIX TO NICS

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16. Abstract

The PIX follow-up project NICS is described. The purpose of PIX was access to X.25, the DATEX-P network of the Federal German Post Office. The development and implementation of "higher" protocols for levels 4-7 in the ISO-Sinn was the actual problem here. Results of the PIX project are given. NICS (Stuttgart Interconnection Network Project) is presented. International Protocols are reviewed.

PAD service is described, which allows terminal access to DATEX-P network of the Federal German Post Office.

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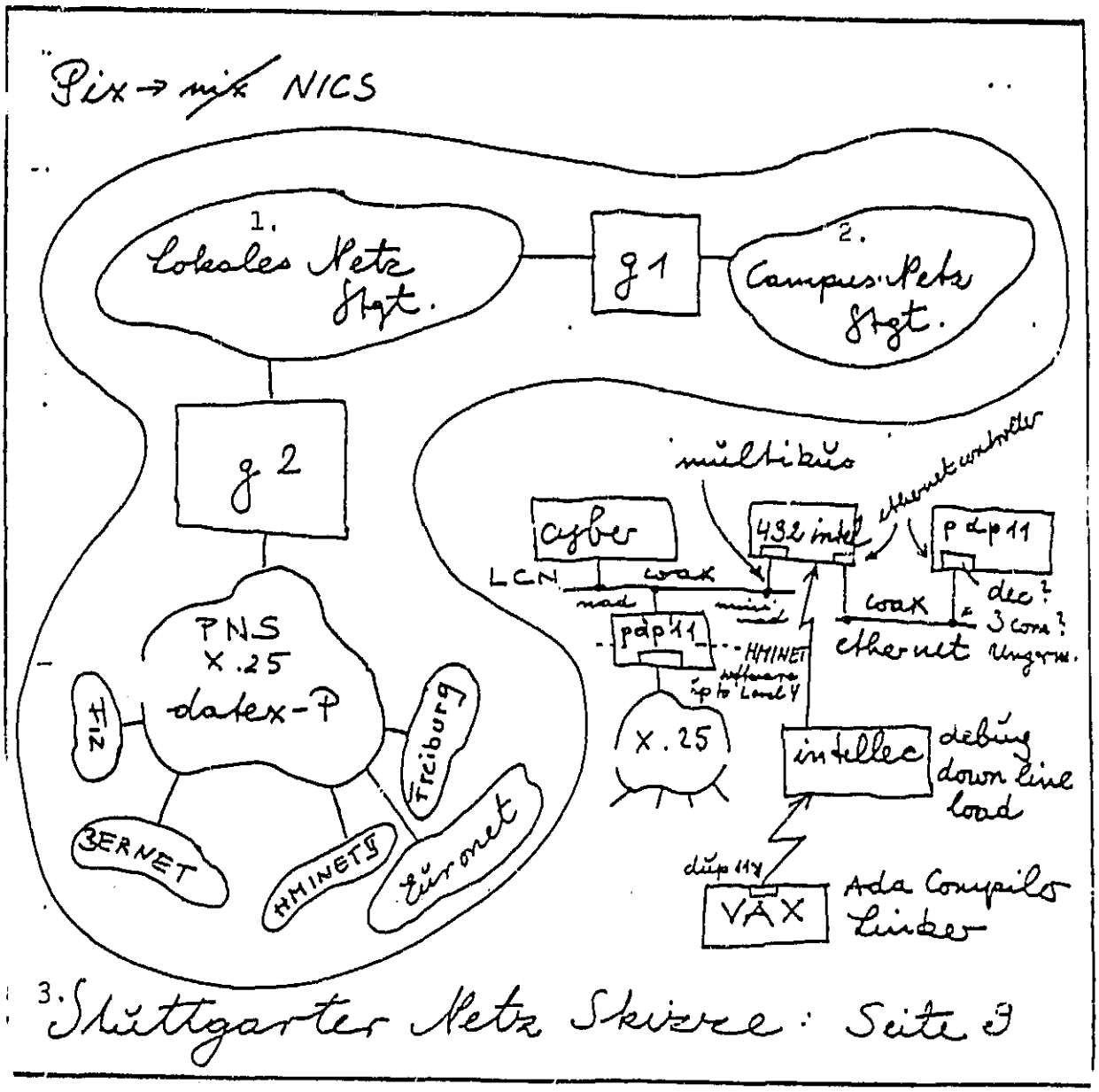
STUTTGART INTERCONNECTION NETWORK PROJECT FROM PIX TO NICS



Key: 1. Local neworks/Stuttgart; 2. Campus Network/Stuttgart; 3. Sketch of the Stuttgart Network: page 3.

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*Numbers in the margin indicate pagination in the foreign text.

STUTTGART INTERCONNECTION NETWORK PROJECT FROM PIX TO NICS /1

0. Summary

The PIX follow-up project NICS is described: the purpose of PIX was the access to X.25, the DATEX-P network of the Federal German Post Office: the development and implementation of "higher" protocols for levels 4-7 in the ISO sense was the actual problem here. NICS generalizes PIX: not just one computer, for example the CYBER 174 was to be connected with the DATEX-P-Network, but two computer networks, once again to be connected with each other. These networks are in the first place a so-called local network of Stuttgart (LNS), consisting of the central RUS units, which were to be connected by a so-called "high speed link," and secondly the campus network of Stuttgart (CNS), represented as a prototype connection "user-mini-RUS station" through the 10Mbit/sec ETHERNET.

Common applications (ISO level 7) were to be developed for these three networks.

NICS is sponsored by the BMFT (Federal German Ministry of Research and Technology) from 1981 to 1983.

1. Computer Network Tasks at the Stuttgart University Under the Aspect of the NICS Project.

Juridico, geographic and technical characterisitics divide the world to be considered here into three network complexes:

S1: The local network of Stuttgart (LNS) integrates the central computer center components into a uniform extendable service complex for the user by means of a fast (several megabits/sec)

file and job transfers; here among other things the following problem is tackled simultaneously: "the next central computer will be a 64 bit machine, that is incompatible with the present units."

S2: The Campus Network of Stuttgart (CNS) aims at connecting the user-mini systems with the central RUS complex. A file and job transfer in the 1 megabit/sec range seems to be hereto the suitable means.

S3: The Public Network of Stuttgart (PNS) provides for the access to and the availability of the DATEX-P-Network of the Federal German Post Office.

The access of local users to the time sharing of different central units should take place from "outside" through an "intermediary," such as for example, is now implemented for asynchronous terminals by the so-called "PACX" of the Gandalf Company; the interactive access to remote computers on the DATEX-P-Network should take place only through one RUS computer and not, for example, through the CNS and LNS.

2. Results of the PIX Project

The PIX ("Pilot Project Complex") working group and the PIX project in Stuttgart were, as you may recall (see BI 5/79 and BI 7/80), ultimately a consequence of the announcement of the Federal German Post Office, that a public X.25 network was to be set up in the Federal German Republic. The BMFT reacted with its sponsoring policy: computer connection projects in the technical and scientific sector should above the X.25 develop "higher" communication protocols, and implement them in a compatible manner. /2

In June 1980 the BERNET Berlin project (Universities and Hahn-Meitner Institute), of Stuttgart were able, with considerable

use of the results obtained for Berlin and the PIX project of the Düsseldorf University, to demonstrate the first "open" computer connection in the Federal German Republic, through a public X.25 service: TR440-, CDC- and Dietz unit exchange jobs through protocols independent of the manufacturers.

From the viewpoint of the country, the participation of Stuttgart and the parallel project in Freiburg in the PIX represented the first step to a computer connection for the Baden-Württemberg Universities.

For the purpose of clarification we may represent once more the physical and logical Stuttgart PIX configuration:

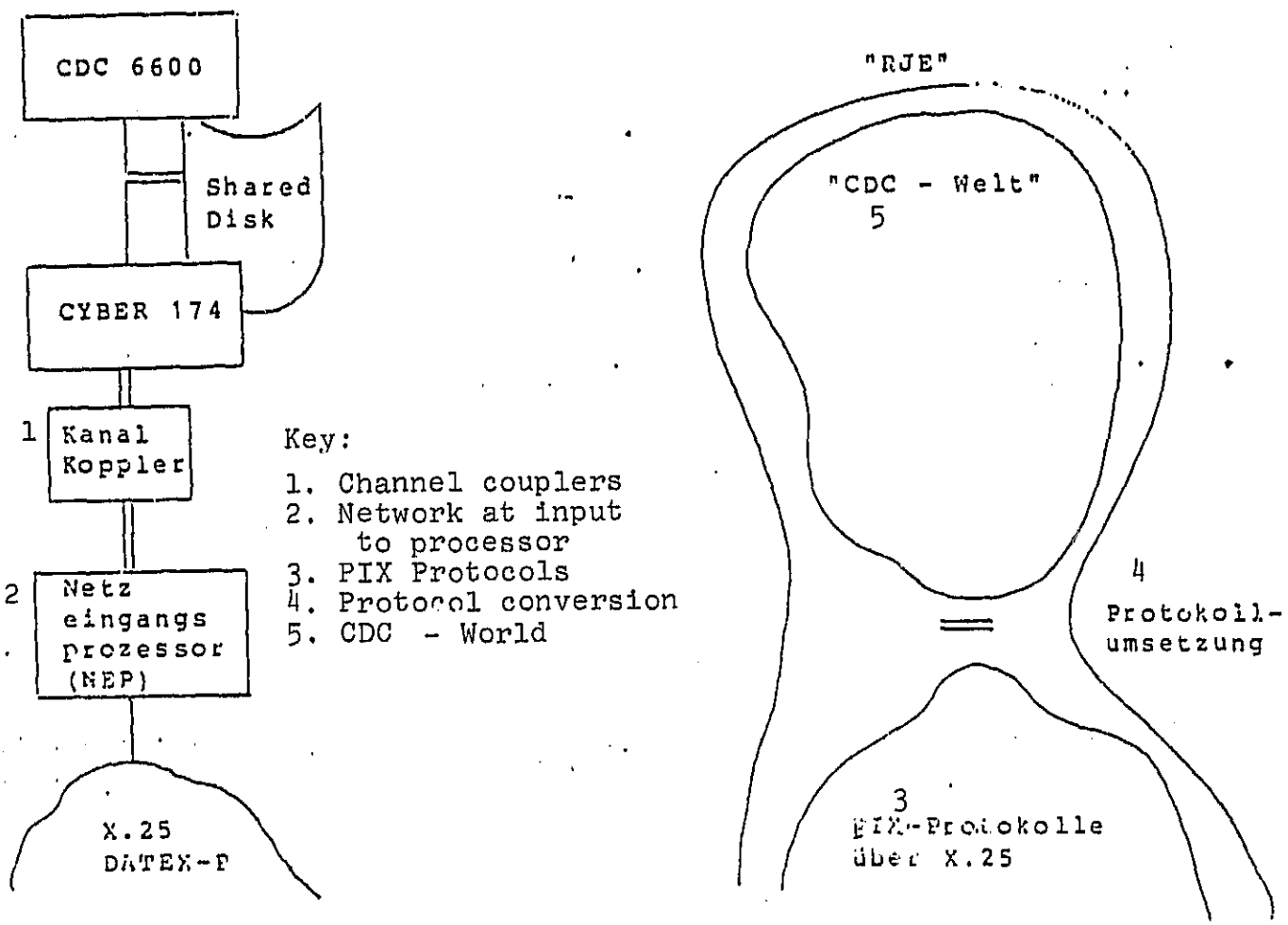


Figure 1. Physical and logical PIX configuration in Stuttgart.

3. The Stuttgart Interconnection Network Project (NICS) /3

3.1. NICS Survey

In the sense of Chapter 1, NICS connects three networks: "LNS", "CNS" and "PNS", by virtue of two computers, the so-called gateways according to the following Figures 2 and 3:

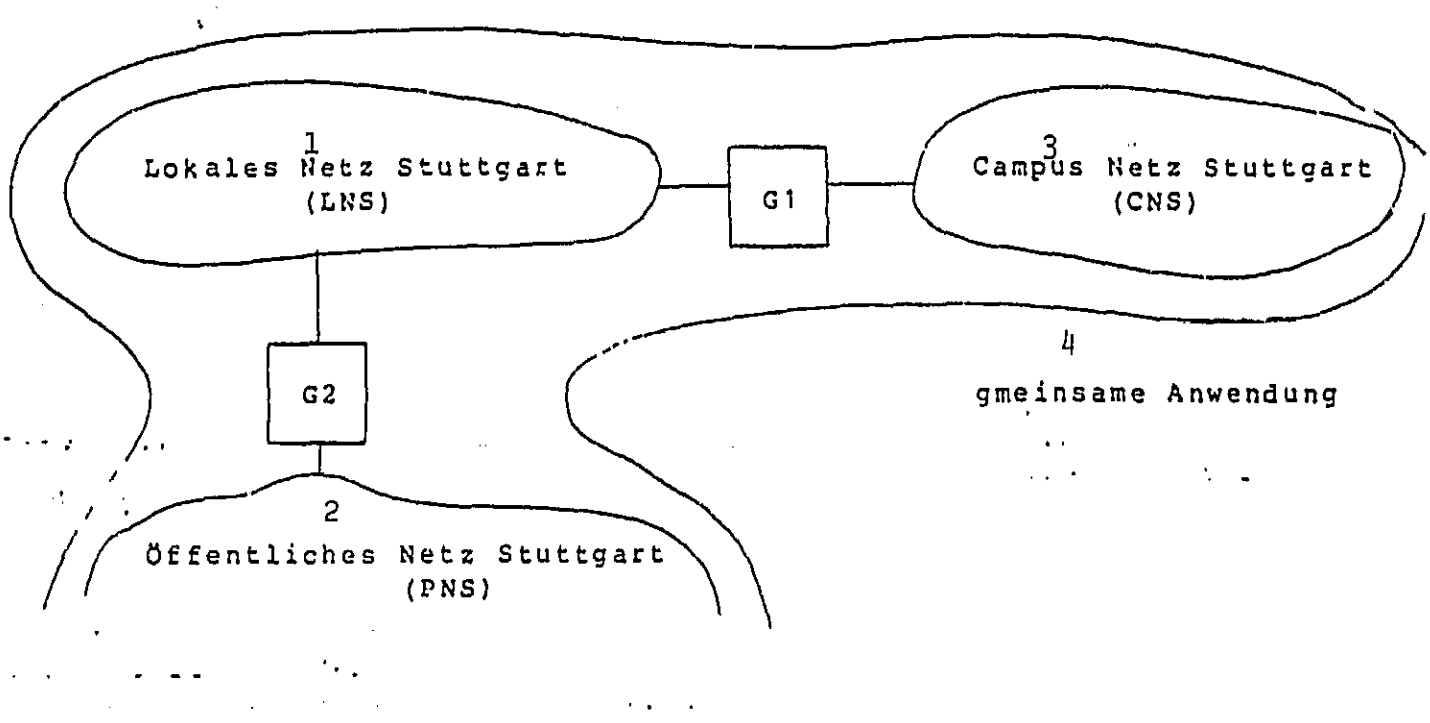


Figure 2. NICS Project: Logical configuration (G1/2:=gateway)

Key: 1. Local network of Stuttgart; 2. Public network of Stuttgart; 3. Campus network of Stuttgart; 4. Common application.

[Note: Figure 2 is continued on the following page]

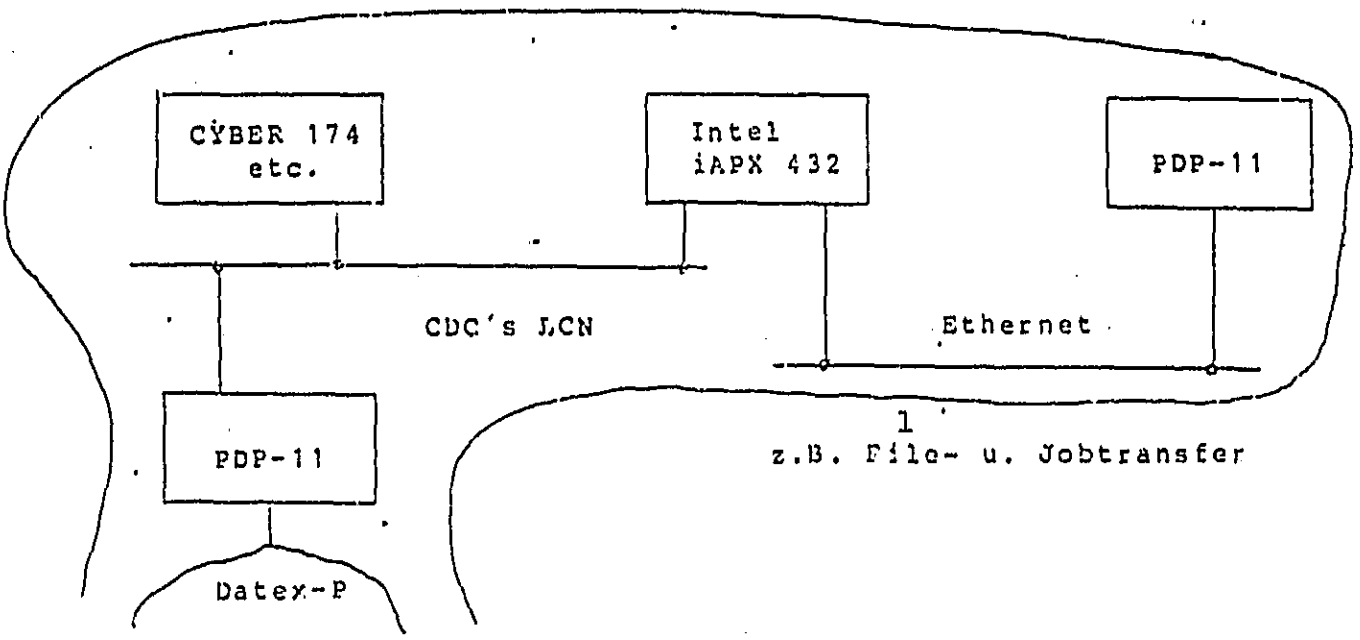


Figure 2. (Second part) NICS Project: Logical configuration (G1/2:=gateway)

Key: 1. For example: File and job transfer

3.2. CDC's LCN as Implementation of the Local Network of Stuttgart (LNS) /4

CDC's Loosely Coupled Network (LCN) is a local area network /CLA78/ in the 50 Mbit/sec class. Topologically it is a bus network (Coax) as shown in Figure 3, which can be extended over about 1 km. CDC offers for its own computers as well as those of the companies DEC (PDP-11, RSX) and IBM (3xxy, MVS) a totally permanent network complex with an architecture similar to the ISO /SCN80/, /ISO80/, see also Appendix 1. The applications provided are file and job transfers (for the CYBER 205 there is an almost quasi-interactive access through the LCN from smaller CYBER machines).

Among other things it is the purpose of NICS, to connect the Intel iAPX 432 as regards software (Intel MULTIBUS, /INT80/) to the LCN and with a suitable protocol hierarchy as gateway to the Campus Network of Stuttgart.

3.3. ETHERNET, a First Element of the Campus Network of Stuttgart (CNS)

ETHERNET is the (famous) Local Area Network, established by XEROX /MET76/, which through cooperation with Intel and DEC, /DIX80/, has good prospects of becoming a standard or the standard for local networks for the 80's /IEE81/.

Besides the above-mentioned companies, HP, Siemens, Nixdorf among others will introduce the ETHERNET.

Topologically ETHERNET, like the LCN is a bus network (Coax), laid out for 10 Mbit/sec in the 1-2 km range.

As compared with LCN, which must "run" on the channels of large computers, a characteristic which is still costly, ETHERNET is "cheap" and suitable under this aspect for cross linking possibly even terminals, besides mini and microsystems.

According to protocol "ETHERNET" according to /DIX80/ only talks at the "level 2 in the ISO sense," that is besides the level 1, it covers only the link level (HDLC, SDLC, DDCMP respectively for point-to-point connections). Therefore if companies wish to offer the ETHERNET, this means only level 2 compatibility for a heterogeneous, "open" computer connection. Thus, for example, DEC will certainly use ETHERNET "under" DECNET instead of an DDCMP connection; there are indeed already the corresponding plans for X.25 (level 3) and DECNET.

As compared with present conditions on the campus, however ETHERNET will represent progress: it will be one of the means able to provide large amounts of experimental data from laboratory computers within compatible times to the RUS central computer.

3.4. The Access to Public DATEX-P Network (PNS)

As gateway between the LNS and the X.25 network of the Post Office, DATEX-P uses within the NICS a PDP-11 under the RSX; the X.25 hardware and software were developed by DEC in cooperation with the Hahn-Meitner-Institute (HMI Berlin, RMINBT II Project) and taken over as a whole by the NICS project; this complex also includes X.29 and a PAD (see Appendix 3). The HMI also took over the implementation of the PIX transport protocol and the file transfer protocol, /MLP80/,/VF 80/.

We may recognize in the PNS partial project of NICS a /5
continuation of the PIX: the PIX protocols end at the gateway to the local network of Stuttgart and are converted into these conventions.

PNS represents moreover the point of view "structure of a computer network for the Baden-Würtemberg Universities": the Freiburg University RZ is also implementing a second project stage; then the results achieved in Berlin (HMINET II and BERNET projects) and at the Dusseldorf University will be transferred jointly to other universities (Siemens Computer types (BS 2000, BS 3000), Dietz, etc.).

3.5. First NIC Results for the RUS User

For the RUS user, the NICS can be paid off first by cooperation with the HMINET II. The X.25-, X.29-, etc., PAD software allow specifically access through the DATEX-P to the German and through the prior connection DATEX-P - EURONET, also other European technical information centers. This may be extended: in the

foreseeable future there will be a DATEX-P - TELENET /TYMENET/ DATAPAC connection (USA and Canada).

4. State of the Art of International Protocol Discussion

The protocol and standard discussion will be touched upon only briefly. The most important "bodies" in the discussion are to our knowledge at present the ISO, the CCITT and perhaps the ECMA also for transport level; in the USA this is followed by the NBS (National Bureau of Standards) with an imposing list of projects along the lines of the above-mentioned groups, while the DoD (Dept. of Defense) follows its own line in the ARPA-Network sequence (catchwords for the DoD: connectionless against connection oriented; too "costly" transport protocol when X.25 is already available as network layer), /DOD80a/,/DOD80d/.

In 1980 the CCITT issued a number of recommendations for the international TELETEX traffic, which cover for the first time practically the entire ISO-OSI hierarchy, /CCI80/.

The CCITT Teletex recommendation S.70 is discussed at present as "Class 0" with classes 1-3 (ECMA influence) for the transport level (level 4) of the ISO, TC97/SC16/WG6, /LEN81/.

And what about NICS? NICS will be maintained at the current level through its potential partners, the GMD, the HMI and the Düsseldorf University; the practical effects of the international protocol discussion do not seem to lie within the NICS planning level. The Teletex recommendations affect possibly, for example, the display text, but this application through the X.25 is in our opinion still far from relevant for universities. More important for universities are the formulations arising for internetworking of local and public networks, for example between ETHERNET and X.25 base networks /NBS81/, /GMD81/.

5. Computer Networks in the 80's /6

The NICS survey given in paragraph 1 must be extended for the 80's by several points. On the application side, the following catchwords may be mentioned: integration of "voice and data," video. Technically there will be a separation between local networks of the bus and ring type on one hand, and digital intermediaries (catchwords: PCM, PCM30, etc.) on the other hand for the above indicated applications; in particular, the telephone exchange will be replaced by such an integrated intermediary system. Such intermediaries are represented today, say by the ISX system of the Datapoint Corporation or the IBS/S40 of the InteCom Company Inc. (naturally the Federal German Post Office will have to wait a little for this).

6. Call to Corporation

The NICS project would welcome the direct or indirect participation in the project of interested users. An indirect participation would consist for example, in informing the RUS of one's interest in the connection of the institute minisystems with the ETHERNET coupling and asking the main suppliers, when for example a suitable controller is available. We could represent direct participation in the form of research work, etc.; the owner of a PDP would naturally be a cooperation partner; a VAX system also also has a unibus.

The Intel 432, besides the corresponding Ada could represent not the least a stimulus for cooperation in some form or other.

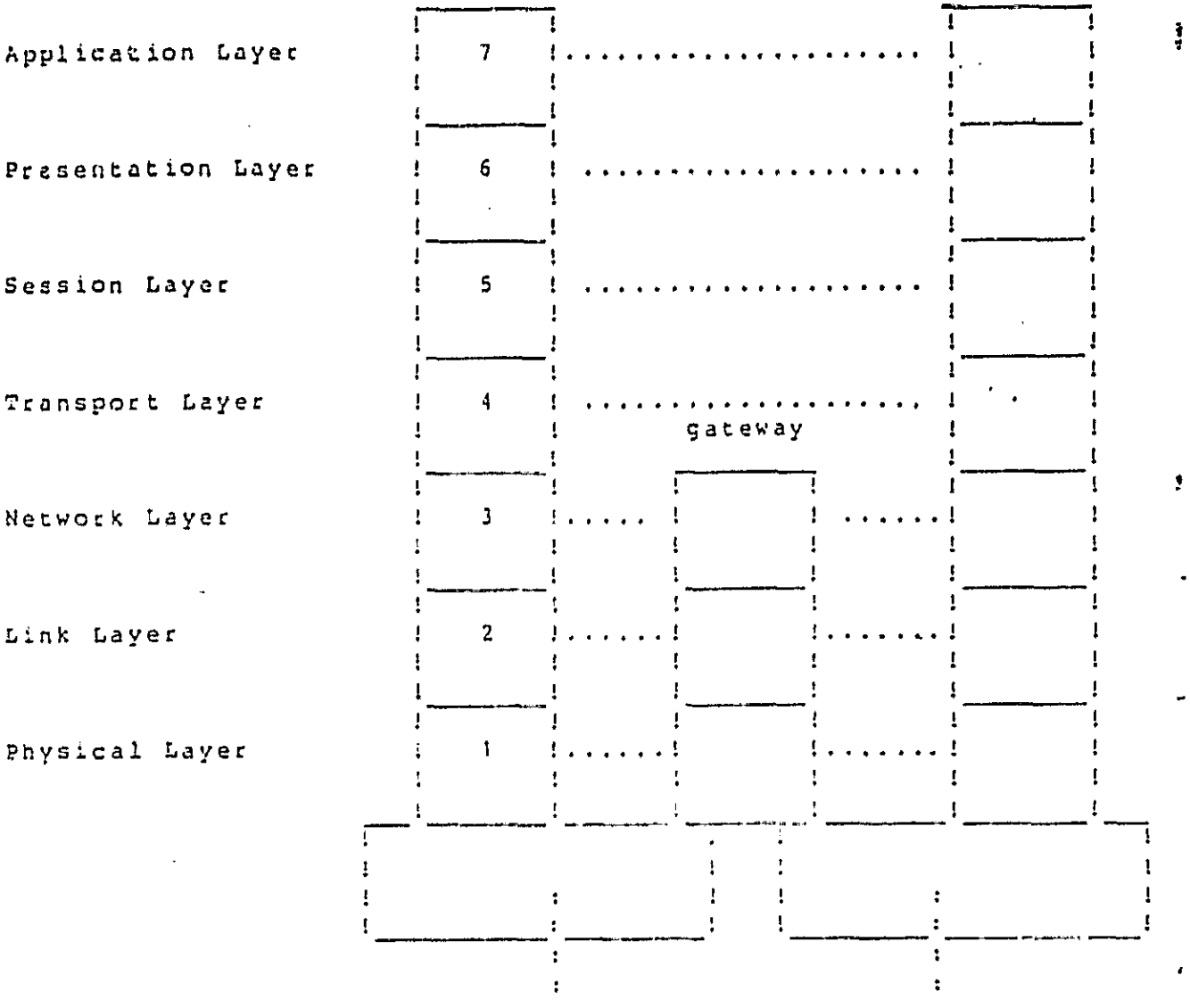
7. Acknowldgements

Besides the above-indicated partners, such as the Freiburg

parallel project, the GMD-IFV and the project of the Düsseldorf University, the Stuttgart PIX followup project NICS would like to thank in particular both the Berlin projects BERNET and HMINET II.

The BERNET software and hardware represented the basis for the first project stage; BERNET "II" has provided by presenting an extensive set of implementation specifications, considerable prerequisites for the success of the NICS. As indicated the entire X.25 etc. comes from the HMINET II, besides the transport and file transfer protocol implementation on the PDP.

Enclosure 1: The ISO Reference Model for Open Systems Interconnection (ISO-OSI)



Appendix 3

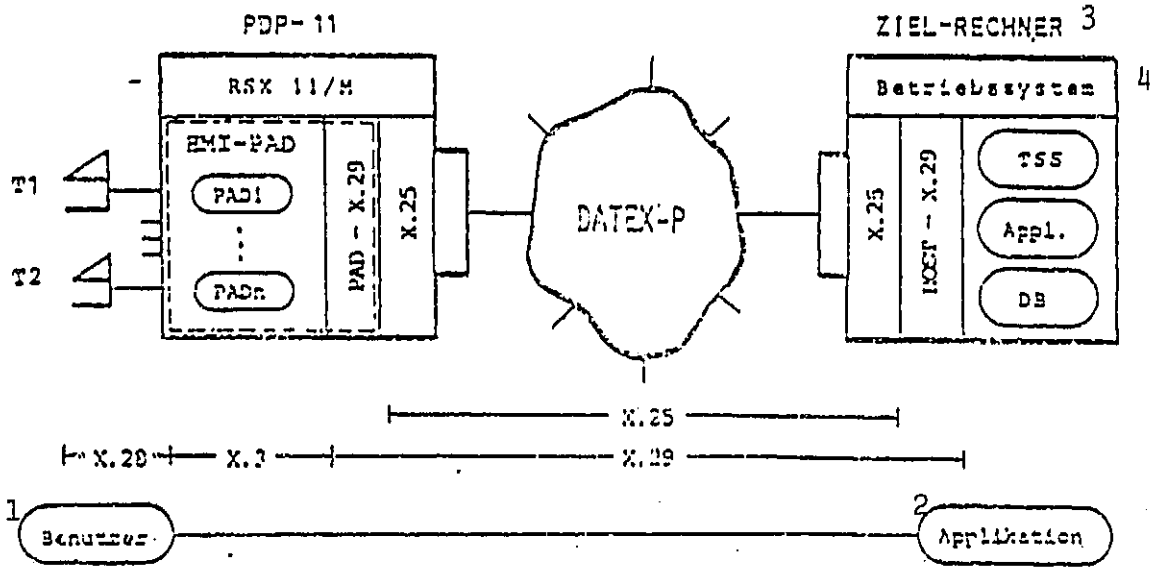
Berlin Hahn-Meitner Nuclear Research Institute

/8

Terminal Access to DATEX-P Network

HMI - PAD

The PAD service (DATEX-P20) allows the connection of symbol oriented, asynchronous terminal to the DATEX-P network of the German Federal Post Office. Thus the possibility is achieved of communication of this terminal with host computers available through the network on the basis of the CCITT recommendations X.3, X.28, X.29. The prerequisite is a DATEX-P compatible X.25 interface in the host computer.



Key: 1. User; 2. Application; 3. Target computer; 4. Operating system

Software PAD in HMI

To allow the terminals which are connected to the host computers access to the DATEX-P network beyond their local use, this PAD service is implemented in the HMI in host computers. Thus the users of these terminals obtain additional access to the operating system functions (TSS, DB, etc.) of the host computers which are connected to the DATEX-P network through the X.25 and have available the X.29 component.

The PAD is determined in its function by the values of the PAD parameters. These parameters take into account both the properties of the connected terminals and the requirements of the corresponding application on the target computer. /9

The values of the PAD parameter can be modified by the terminal user by PAD commands and by the target computer through PAD messages. The following function may be controlled, among others, by the PAD parameters:

Terminal echo, data forwarding, break, terminal input/output.

The parameters of HMI-PAD correspond to the CCITT recommendation X.3 and DATEX-P20 and are extended by private parameters for user friendly terminal input.

The PAD is characterized by 2 functional states:

In the command state, the terminal user may accomplish the following:

- read and alter the PAD parameter,
- produce, reset and eliminate an X.25 connection (SVC) to the target computer,
- send interrupt signals to the target computer and,
- provide the transition to the data transmission state.

These PAD commands correspond to the CTITT recommendation X.28 and DATEX-P20.

In the data transmission state, the terminal inputs of the user are transmitted to the traget computer taking into consideration the values of the PAD parameters. From this state, they may be returned to the command state.

Pad messages are control data between PAD and the target computer and correspond to CCITT recommendation X.29.

The HMI-PAD is implemented for all PDP-11 computers with the operating system RSX-11M/M. Here the functional extent of "full duplex terminal driver" is used. The PDP-11 computers are connected through the microprocessor interface KMD-11 and the corresponding X.25 user interface PACKETNET of the DIGITAL Company, to the DATEX-P network. The HMI-PAD is installed as "user task" and can be called upon for each user as a standard service program.

In the HMI on the PDP-11 computers, printing terminals (for example LA36, DECWRITER) display screen terminals (for example VT52, VT100) and graphic terminals (for example TEXTRONIX, Plasma Display) may be used.

Typical PAD applications are among others, program establishment and costs as well as experimental data evaluation by means of interactive graphic systems on remote computers.

Appendix 4: Literature /10

/CCI80/ CCITT recommendations for the International Telex Service 1980. (also Rec. S70 (Transport) and Rec. S. 62 (Session, Presentation, P.C.).

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/IEE81/ IEEE Project 802 FRD, Version 5.2, Feb. 5, 1981. Layer 2/Layer 3 Interface Service Specification Version 1.0.

/INT80/ IEEE Proposed Microcomputer System Bus Standard (P796 Bus) October, 1980. (This is the Intel MULTIBUS P.C. proposed for standardization).

/ISC30/ ISO/TC97/SC16/537: Data Processing - Open Systems Interconnection. Basic Reference Model. Dec. 3, 1980.

/LCN80/ Control Data Corporation: Loosely Coupled Network. 1980.

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/MEO76/ Metcalfe, R.M., Boggs, D.R.: ETHERNET: Distributed Packet Switching for Local Computer Networks. CACM 19/7 July 1976.

/MLP80/ Henkel, L.: Message Link Transport Protocol. Hahn-Meitner-Institut. Berlin 13.10.1980.

/NBS81/ National Bureau of Standards: Specifications and Analysis of Local Area Network Architecture Based on the ISO Reference Model. Draft Report. April 1981.

/VF 80/ Henkel, L. et al.: HMINET II Virtual File. Modif. 2 15 August 1980 (in cooperation with BERNET).

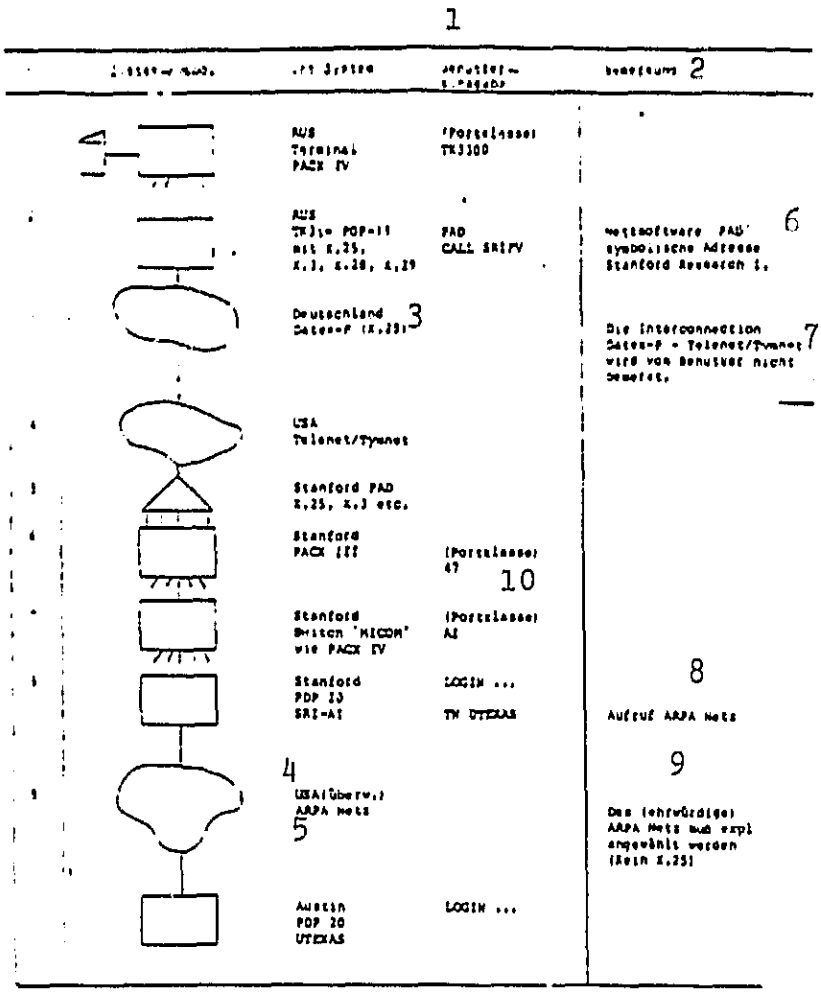

Figure 3. Session configurations
Stuttgart - Austin

Key: 1. User input; 2. Remark; 3. Germany; 4. Monitoring; 5. Network; 6. Network software "PAD" symbolic address/ Stanford Research I.; 7. The interconnection DATEX-P - Telenet/Tymnet is not noticed by the user; 8. Calling upon ARPA network; 9. The (time honored) ARPA network must be selected explicitly (no X.25); 10. Port class

The extent of the user aids in the coordinated ARPA network surroundings is surprising. For example if we have the intention of sending without previous knowledge news through the CSNET to the above-indicated author, one would first press "HELP" and one would obtain the printout according to Figure 5.

Then we would continue with "HELP ?", see Figure 6.

Figure 4 shows parts of the session protocol.

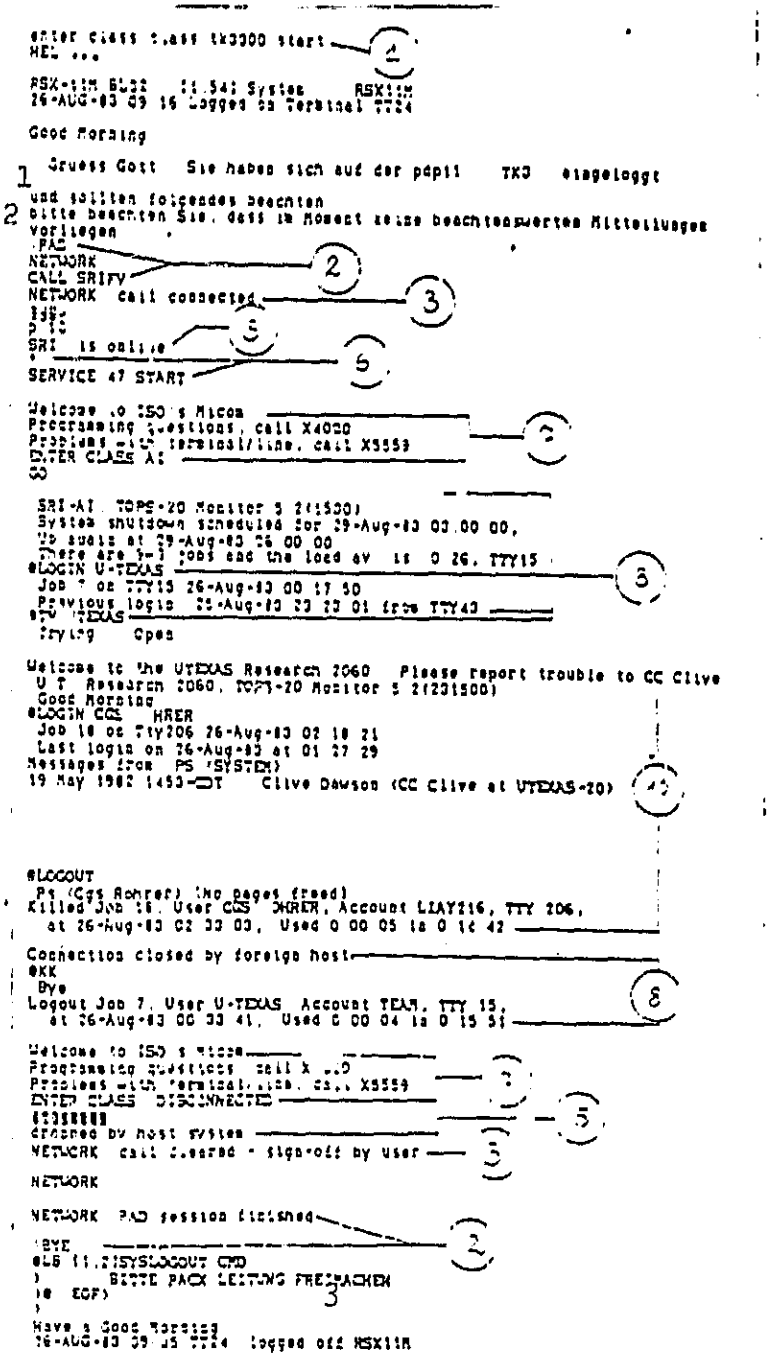

Figure 4. Session protocol
Stuttgart - Austin

Key: 1. And please note the following; 2. Please note that at the moment there are no significant communications available. 3. Please release PACX line.

```
@HELP

HELP Command xxxx
The HELP command prints helpful documentation on
various system features.  The command

  @HELP
will print this message on your terminal.

  @HELP NAME
will look for, and print out information about the system
feature named is "NAME".  For example,

  @HELP EDIT
will print out information about the EDIT program.

  @HELP ?
will give a list of features for which HELP is available and
retype @HELP  to wait for any additional input.

(End of HELP HLP)
```

Figure 5. "HELP"

It may be seen that "CSNET" is a HELP item, therefore if one indicates "HELP CSNET" we obtain accordingly Figure 7. We find also there how to send a news item.

/13

```
@
@HELP  ' one of the following
  Ai
  Alter-Mode-Command-Edit
  Archive
  Arthur
  Attn
  Backup
  Batch
  Bbcast
  Bboard-Rules
  Bliss10

  Cpm
  Cref
  Cristy
  Crypt
  Csnet
  Ddt
  Deliver

  Dwatch
  Macro
  Mail
  Matlib
  Maxvfu

  Ms
  Multi-Forking
  Netstat
  Odump
  Opr
  Pcl

  Watch
  Wc
  Whois
  Xsearch
  Xtype
```

Figure 6. Extract from "HELP ?".

```
@HELP CSNET
CSnet is a collection of academic and industrial sites that have set up
a computer network  It is intended to provide mail and file transfer
among all of these sites  CSnet supports two kinds of hosts  Arpanet
and Phonenet  This file will not mention Arpenet hosts further, since
they are directly accessible to us anyway  However we generally have
access to Phonenet hosts only by virtue of CSnet.  Phonenet hosts dial
up one of the CSnet relay facilities on a regular basis to handle
requests to and from CSnet  As far as I know, Phonenet supports only
mail at the moment

Mail to Phonenet hosts must go through either UDEL-RELAY or RAND-RELAY.
In general Udel is used for hosts on the East Coast and Rand for hosts
on the West Coast  To send mail to a Phonenet host, use MM just as you
would for local mail  However the address that you use after the "to "
or "cc " prompt must have a special format  "user host@xxx-RELAY".  Here
is an example

@mm send
 To  smith buffalo@udel-relay
 cc  smith alabama@rand-relay
 Subject  test of phonenet
 Message (ESCAPE to MM command level, ^Z to send)
This is a test of sending mail to you via phonenet
^Z
Processing local mail
  smith buffalo@udel-relay -- queued
  smith alabama@rand-relay -- queued
@
```

Figure 7. Extract from "HELP CSNET".

"HELP" had also indicated "NETSTAT" as entry. For example /14
to obtain network information, we press "NETSTST". Is it consistent with "HELP ?", then we obtain "?" after the NETSTAT-prompt "*", the list of possible NETSTAT commands (at that moment). Then we also feed in "TCP" and obtain a survey of the currently existing Transport Control Protocol connection, which our computer maintains precisely (the machine in Austin). It is nighttime, we identify our single track, we come from Stanford "SRI-AI", see Figure 8.

```
$NETSTAT
*? A command, one of the following
 CONNECTIONS   HELP
      HOSTS
     NCP
    QUIT
 TCP
*
TCP Connections
J,JCN TVT RCV SND LPORT FPORT  FOREIGN-HOST     RCV-SEQ  RCVW    SND-SEQ  SNDW
 6,1      FIN FIN    25     0  0 0 0 0              0   964          0     0
 1,1      FIN FIN    79     0  0 0 0 0              0   964          0     0
J18   206 -3- EST    23  1892  SRI-AI      2794782800   885 2786132583   839
 0,2   0 FIN FIN    23     0  0 0 0 0              0   964          0     0
 0,1      FIN FIN    21     0  0 0 0 0              0   964          0     0
```

Figure 8. Network statistics via "NETSTAT" commands and and connections.

If then there are still "HOSTS", we obtain a survey over the giant ARPA network "cultural group"; the table shows almost 900 entries. We can identify the RAND-RELAY indicated in Figures 1 and 7, the dark STUTTGART-TAC as well as the computers, representing DFVLR1 and 7.

3. Outlook /15

The technical components required for the above-indicated communication possibilities are basically available at the computer center. The X.25 hardware and software were financed within the Stuttgart Interconnection Network Project (NICS), see BI 9/81, by the BMFT. The PAD on PDP-11 was developed in the BMFT project HMINET II at the Hahn-Meitner Institute in Berlin and taken over in cooperation by Stuttgart.

Naturally there can be no talk yet of a sure administration of corresponding mass services. User requirements, which arise by indicating the technical possibilities, are however a welcome input for the corresponding development of the computer center.

Figure 9. Network statistics via "NETSTAT" ARPA network hosts.

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P. Christ